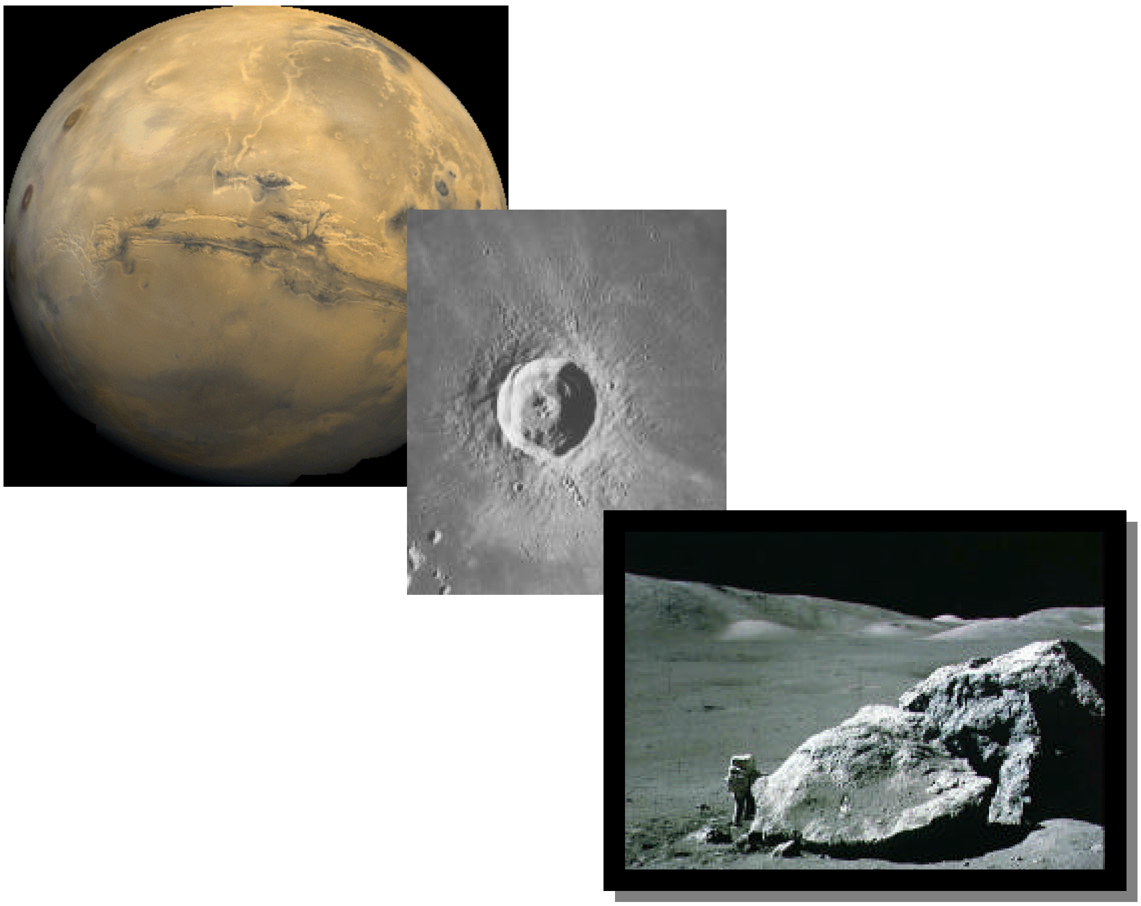
USGS Educational Outreach



Moon Module

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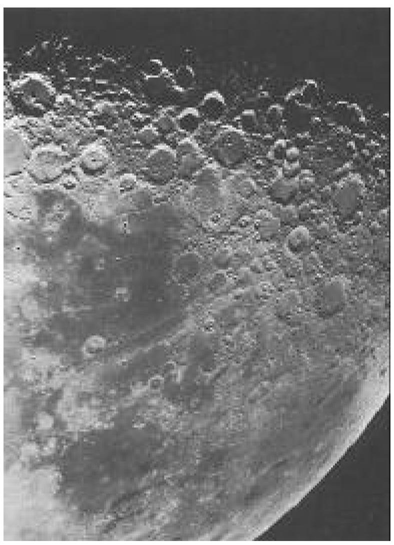
Introduction

The Moon is our closest neighbor in space. Therefore, scientists have been able to gather large quantities of data about it's surface features, inner composition, and geological and formational history. We have even sent humans to the Moon to conduct geological exploration and experiments.

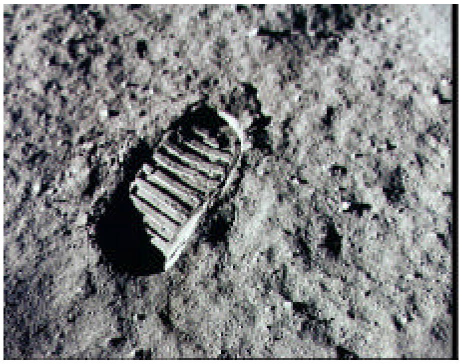
The Moon orbits the Earth at a distance of 238,855 miles or 384,400 km and has a diameter of 3,476 km, approximately one-fourth the size of Earth. The Moon's gravity is one-sixth that of Earth's gravitational pull. The Moon is extensively scarred by meteor impacts and shows evidence for volcanism and tectonic processes, but there is no substantial evidence for water. There is no atmosphere on the Moon, so it is incapable of supporting life, as we know it. Furthermore, the lack of any atmosphere causes drastic temperature changes. When the Moon is receiving light from the sun, temperatures can reach 235º F. Meanwhile, the side of the Moon not facing the sun can reach temperatures as low as –261ºF. Although the Moon has no atmosphere, evidence from the 1994 Clementine mission suggested that there may be water ice in some deep craters near the Moon's south pole which are permanently shaded. This has now been confirmed by Lunar Prospector. There is apparently ice at the north pole as well.



Geology of the Moon

There are two primary types of terrain on the Moon: the heavily cratered and very old **lunar highlands** and the relatively smooth and younger **lunar maria**, meaning seas in Latin. The maria are huge impact basins concentrated on the near side of the Moon that were later flooded by molten lava. These lava seas cover approximately 16% of the Moon's surface. No one knows exactly why lava erupted here. The Moon's crust is thinner on the near side so it may have been easier for magma to raise through the thinner crust flooding the low lying impact basins. On the far side the crust is much thicker. Photographs taken of the Moon's surface show sinuous lava channels called **rilles**, and volcanic domes, cones, and collapse pits. These features support the theory that there was once active volcanism on the Moon.

The surface of the Moon is covered with impact craters. These craters are very old and tell us that the Moon's surface has changed very little since it was formed. Why don't we see as many craters on the Earth's surface? Most of the craters on the near side are named for famous figures in the history of science such as Tycho, Copernicus, and Ptolemaeus. Features on the far side are named after more recent people such as Apollo (after the Apollo spacecraft missions), Gagarin and Korolev (Russian names). Some craters are surrounded by bright rays formed from material that was ejected out of the crater during impact. Using these rays, scientists can determine the relative ages of craters and different regions on the Moon.



Most of the surface is covered with **regolith**, a mixture of fine dust and rocky debris produced by meteor impacts. Regolith consists of individual mineral grains and rock fragments that are sometimes cemented together by impact-melted glass. The regolith is 2 to 8 m deep in the maria and can be up to 15 m deep in the lunar highlands.

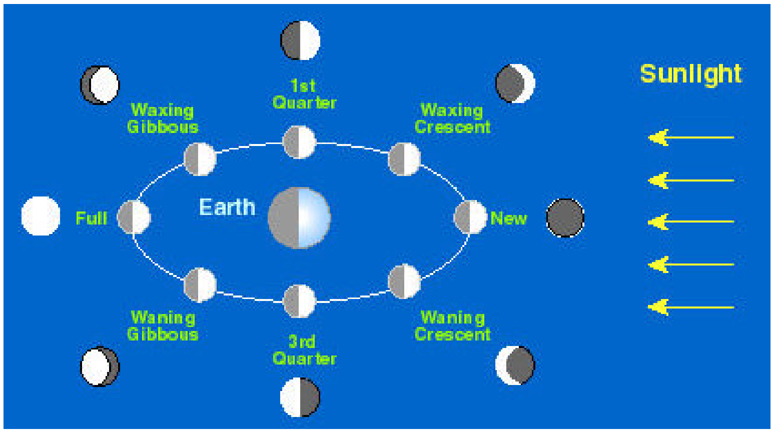
Origin of the Moon

Before the Apollo missions, there were three principal theories on how the Moon might have formed. The *co-accretion* theory asserted that the Moon and the Earth formed at the same time, when the rest of the solar system formed. The *fission* theory proposed that the Moon split off of the Earth. Finally, the *capture* theory stated that the Moon formed elsewhere and was then captured by the Earth's gravity. None of these theories seemed completely scientifically sound. With new information from lunar rocks brought back by the Apollo astronauts, the *impact* theory was proposed. It asserted that the Earth collided with a very large object (as big as Mars or more) and that the Moon formed from the ejected material. This theory is now widely accepted.

The Moon in Space

It takes the Moon 27.3 days to orbit the Earth, which is also the time it takes for it to rotate once on its axis. Therefore, the Moon's day is equal to it's year. This is also why we only see one side of the Moon whenever we look at it. The side we see is called the near side and the side we can't see is called the far side or the dark side. Despite the name dark side, both sides of the Moon receive light from the sun for equal amounts of time.

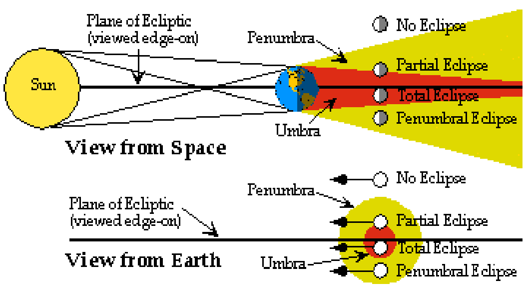
As the Moon revolves around the Earth it appears to change shape. During each lunar orbit (a lunar month), we see the Moon's appearance change from not visibly illuminated through partially illuminated to fully illuminated, then back through partially illuminated to not illuminated again. Although this cycle is a continuous process, there are eight



Phases of the moon.

distinct, traditionally recognized stages, called phases. The phases designate both the degree to which the Moon is illuminated and the geometric appearance of the illuminated part. The phases of the Moon are caused by the relative positions of the Moon and sun in the sky.

One consequence of the Moon's orbit about the Earth is that the Moon can shadow the sun's light as viewed from the Earth, or the Moon can pass through the shadow cast by the Earth. The first is called a **solar eclipse** and the second event, a **lunar eclipse**.



Positions of the Earth, sun, and Moon during a lunar eclipse.

From 1969 to 1972 six Apollo missions visited the Moon. Many of the astronauts that walked on the Moon trained for the geological aspects of their missions in Flagstaff, AZ with the help of the U.S. Geological Survey's Branch of Astrogeology. Flagstaff was a good place to train because it has a variety of geological features, including volcanoes, lava flows, and Meteor Crater. Gene Shoemaker, who founded and headed the Astrogeology Branch, aided in the training of the Apollo astronauts.

The Future Moon

Since the end of the Apollo missions in 1972, humans have not returned to the Moon. However, data from the Clementine and Lunar Prospector missions was compiled into detailed maps of the entire surface of the Moon. These missions also took additional surface composition readings. The future of Moon exploration is still uncertain. However, the SMART-1 (Small Missions for Advanced Research in Technology 1) is a lunar orbiter mission scheduled for launch in 2003. It was designed to test spacecraft technologies, specifically, a solar-powered ion drive. The primary scientific objectives of the mission are to return data on the geology, morphology, topography, mineralogy, geochemistry, and exospheric environment of the Moon in order to answer questions about planetary formation accretional processes, origin of the Earth-Moon system, the lunar near/far side dichotomy, long-term volcanic and tectonic activity, thermal and dynamical processes involved in lunar evolution, and external processes on the surface.

Finally, the Moon also has the potential for supplying natural resources that may soon be depleted from the Earth. This might once again result in setting our sights on another manned mission to the Moon.

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? **Image of body impacting Earth:** http://www.abc.net.au/science/news/img/moonimpact.jpg

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